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THE TOBACCO BEETLE AND HOW TO PREVENT DAMAGE BY IT

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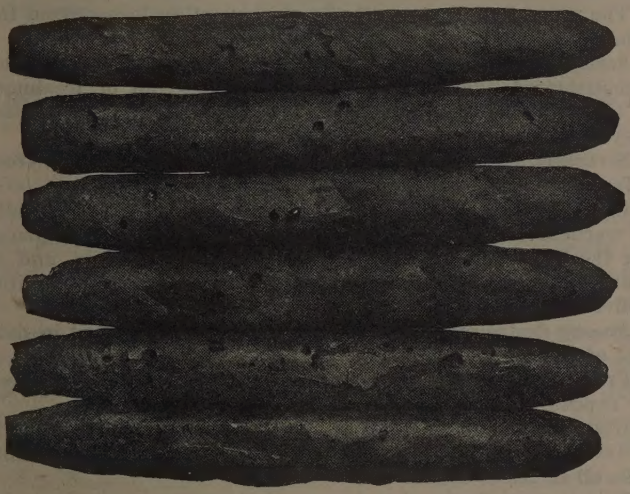

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THE TOBACCO BEETLE is a reddish-yellow or brownish-red beetle, about one-tenth of an inch long, the larva of which attacks cured tobacco and tobacco products, riddling them with its tunnels and rendering them unfit for use. It is found in practically all countries and occurs wherever large quantities of leaf or manufactured tobacco are handled or stored. It does not attack growing tobacco.

The more important methods of preventing losses from the tobacco beetle may be summarized as follows:

Scrupulous cleanliness in the factory or wholesale or retail establishment, including the prompt destruction or treatment of all refuse material, damaged stock, etc., in which the beetles may breed.

Screening or otherwise protecting the finished product from infestation.

Constructing or refitting packing or storage rooms, especially in warm localities, so that they will be free from hiding places for the beetles and can be cleaned quickly and easily, and so that beetles which may be present in other parts of the building will be excluded.

Among destructive agencies which may be employed in control of the insect are:

Freezing. (Treatment by cold storage or, in cold climates, by exposure to low temperatures.)

High temperatures or steam. (A temperature of from 125° to 140° F. continued for several hours, or 150° for a short time, kills all stages of the insect.)

Trapping or destruction by mechanical means.

Fumigation with carbon disulphid or hydrocyanic-acid gas.

The modern practice of storing leaf tobacco in hogsheads in specially constructed buildings or sheds, giving practically out-of-door conditions and variations of temperature, furnishes, in cool climates, an effective means of reducing or preventing injury to the classes of leaf tobacco which may be stored in this manner.

THE TOBACCO BEETLE[1] AND HOW TO PREVENT DAMAGE BY IT.

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MOST tobacco dealers and manufacturers are more or less familiar with the tobacco or "cigarette" beetle. This small beetle is an indoor species, is the most widely distributed of all insects affecting tobacco, and is one of the worst pests of the tobacco industry. Usually it is present in some stage at all times in practically all tobacco warehouses, cigar and tobacco factories, and extensive wholesale or retail establishments. It lives within its food substance during all stages of its existence. For this reason it is spread easily, and its capacity for injury is large. With tobacco, as well as with its other food substances, of which it has a variety, the actual quantity consumed is usually of far less importance than the presence of refuse, dust, dead bodies of the beetles, etc., which soil the manufactured product or make it unsalable and worthless. In a valuable product like fine leaf tobacco used as wrapper, or in expensive cigars or cigarettes, a very few beetles are capable of causing serious damage in a very short time. (See illustration on title-page.)

LOSSES DUE TO THE TOBACCO BEETLE.

Losses occasioned by the tobacco beetle, either directly or indirectly, occur wherever tobacco or tobacco products are handled. Statements received from manufacturers show that the loss at the factories is large, estimates from some of the larger concerns ranging from $5,000 to $25,000 per year. This, however, probably represents only a small part of the loss from damage to cigars, cigarettes, and manufactured tobacco in the hands of the jobbers and retailers. A heavy loss also occurs from damage to leaf tobacco, but it is difficult or impossible to obtain even an approximate estimate of the total loss.

[1] *Lasioderma serricorne* Fabricius; order Coleoptera, family Ptinidae.

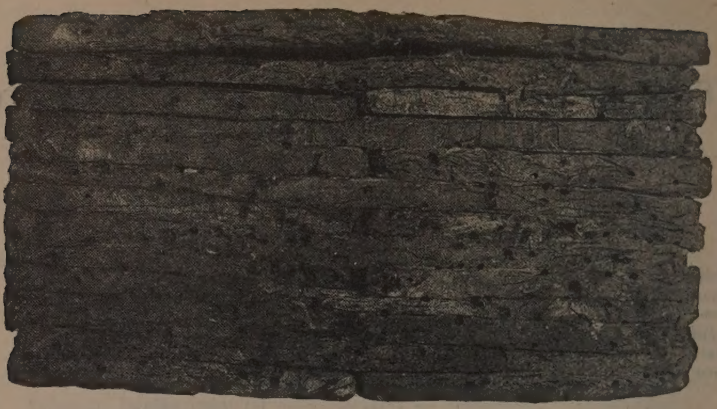

FIG. 1.—Chewing tobacco injured by the tobacco beetle (*Lasioderma serricorne*.)

CHARACTER OF INJURY.

Injury by the tobacco beetle is almost entirely the work of the larvæ, or young. The adults, or beetles, do not seem to injure tobacco directly in any way except when burrowing out after transforming from the pupa or resting stage.

This insect damages cigars and pressed tobacco by eating out or burrowing small cylindrical tunnels and leaving them filled with a mass of dust and excrement. In cigars the holes sometimes extend straight through from one side to the other; in other instances they wind about through the filler of the cigar so that a large part of the interior is destroyed without much evidence of injury showing on the wrapper. The larvæ often work between two closely packed cigars, slitting the wrapper lengthwise for some distance. In a box or package a single larva may injure several cigars. The pupal cells frequently show between closely pressed cigars or on the edge of the band. Dust and refuse from feeding collect in the bottom of the box and between the cigars. Injured cigars do not draw well and burn unevenly, and dust is drawn into the mouth of the smoker.

In cigarettes holes are bored through the wrappers and frequently through the cork tips. The interior of the cigarette is filled with refuse, and the wrapper becomes soiled and discolored. Injury is more likely to occur in cigarettes made from the sweeter, milder types of leaf, such as are used in the more expensive grades. Fine Turkish tobaccos are especially liable to infestation.

Smoking and chewing tobaccos often become badly worm-eaten (fig. 1). In the pressed kinds galleries are formed, and in chewing tobacco the wrapper is cut and the edges furrowed (fig. 2). Granulated and fine-cut tobaccos become mixed with the dust and refuse from feeding and with dead bodies of the adults. Pupal cells occur on the sides of the container or in the tobacco. Holes are found in the paper or tin-foil wrapping.

Leaf tobacco is affected in much the same manner as cigars (fig. 3). The larvæ bore holes in every direction through the leaves, and the tobacco becomes soiled with dust and refuse. Fine wrapper becomes worthless. In leaf tobacco used for filler, for manufactured tobacco, or for snuff, the damage is confined more to the tobacco actually consumed by the larvæ than it is in the manufactured products, the mere sign of infestation making the finished product unsalable and worthless.

DESCRIPTION OF THE INSECT IN ITS DIFFERENT STAGES.

The egg.—The egg of the tobacco beetle is a small, pearly white, oval object about one-fiftieth of an inch in length. Owing to its small size and to the fact that commonly it is laid in creases or folds of the leaf, it is not seen readily, and to many persons familiar with the other stages of the insect is an unfamiliar object.

The larva, or grub.—The larva, grub, or worm stage of the insect is most likely to be noticed in infested material. The larva when

FIG. 2.—Pressed cut smoking tobacco showing burrows of larvæ and exit holes of adults of the tobacco beetle.

fully grown (fig. 4, *a*) is about one-sixth of an inch in length and yellowish white in color. It is fleshy and grublike in appearance and usually lies in a curved position. The head is pale brown and the body is covered with long, silky, yellowish-brown hairs, to which particles of the food substance or refuse adhere, giving the larva a somewhat dusty or dirty appearance. The legs are short and pale

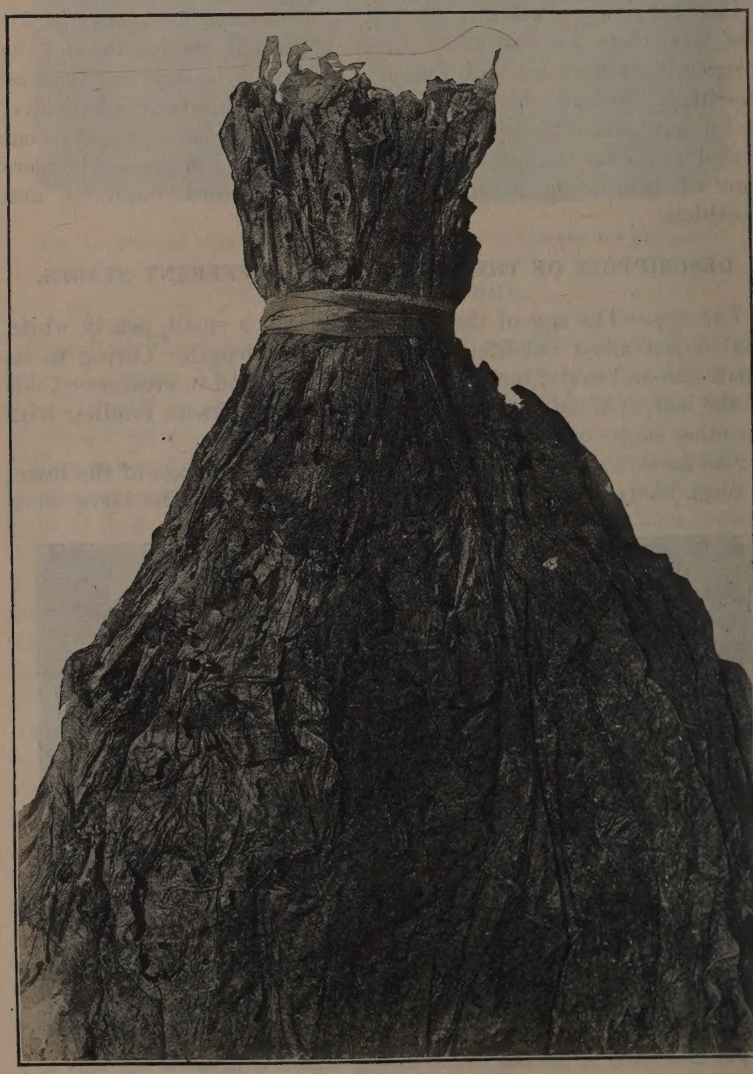

FIG. 3.—Cigar tobacco showing work of the tobacco beetle.

brown. When newly hatched from the egg the larva is very minute, being only about one-fiftieth of an inch in length, and is more active than when more fully grown.

The pupa.—The pupa (fig. 4, *b*) is an inactive or quiescent stage which the insect assumes before transforming to the adult, or beetle. The pupa period is passed normally within a closed cell composed of small particles of the food substance and refuse cemented together with a secretion of the larva. The pupa is about one-seventh of an inch in length. It is white when first transformed from the larva stage, but before becoming adult it gradually assumes a brownish tinge, the eyes becoming reddish or reddish brown. It lies on its back in the pupal cell. Should the cell be broken open and the

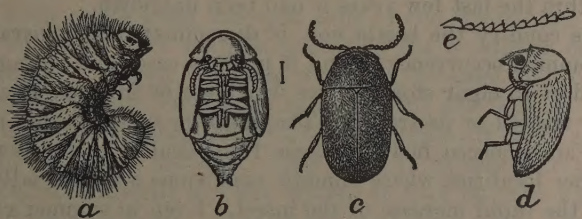

FIG. 4.—Tobacco beetle: *a*, Larva; *b*, pupa; *c*, adult; *d*, side view of adult; *e*, antenna. *a–d*, Greatly enlarged; *c*, still more enlarged. (Chittenden.)

pupa removed, transformation is completed in an apparently normal manner, providing the pupa is protected from rapid evaporation. When infested leaf tobacco is handled, many bare pupæ may be seen which have been dislodged from the fragile cells or cocoons between the leaves of tobacco.

The adult, or beetle.—The beetle (fig. 4, *c–e*) is the fully developed, or adult, stage of the insect. It is uniformly dull reddish yellow or brownish red. The head is broad and the eyes are small. The head is bent down nearly at right angles with the body, giving the beetle, when viewed from the side, a characteristic humped appearance. The beetles vary greatly in size, the average length being about one-tenth of an inch. The female beetles average somewhat larger than the males.

DISTRIBUTION AND DISSEMINATION.

Commerce has served to distribute the tobacco beetle widely, and probably this insect occurs now in all countries having a temperate, subtropical, or tropical climate. In warm tobacco-growing countries such as Cuba and the Philippines, where the bettles are numerous and breed continuously throughout the year, they are being sent out constantly to other countries in shipments of cigars or in leaf tobacco. The nature of their food and their habit of living and breeding con-

tinuously in their food substance aid in their spread without much effort on their part.

The increase and spread of the insect in tobacco factories in this country within comparatively recent years has been very noticeable. Experienced tobacco dealers and manufacturers attribute this to the more general use of steam for heating factories and other buildings. The higher and more uniform temperatures maintained make breeding conditions more favorable for the insect, and the chance that development will be checked or the insects killed out by the cold weather is not as great as before steam heat was employed.

The recent rapid expansion of the tobacco industry has carried the pest, in leaf tobacco or in tobacco products, to many localities where until within the last few years it had been unknown.

In this country the beetle now is disseminated so generally that it is a common occurrence to find it in show cases and storage rooms or humidors in cigar stores where worthless or infested stock is not properly treated or destroyed. The majority of shipments returned to cigar and tobacco factories come from dealers in the South and from other localities where climatic conditions are especially favorable for the rapid increase of the insect. Even in summer comparatively few complaints come from dealers in certain of the Northern States and Canada. In view of these facts, when damaged goods are returned to the manufacturers after having been in the hands of the dealers for some time, it is always possible that the product was not infested when shipped out from the factory.

FOOD SUBSTANCES.

The tobacco beetle feeds upon a variety of dried vegetable substances and upon a few of animal origin. Its more common food is cured leaf and manufactured tobacco. In drug stores and grocery stores often it is found infesting dried roots and leaves of certain kinds and pressed yeast cake. In drug stores frequently it becomes a serious pest and causes considerable loss. Numerous cases of injury to plush upholstering in furniture and to dried plants in botanical collections have been recorded. The insect also feeds upon tobacco seed.

LIFE HISTORY AND HABITS.

THE EGGS.

Period of incubation.—The egg stage at ordinary temperatures in summer lasts from 6 to 10 days. In warm weather during summer it averages about 8 days. Eggs kept at a constant temperature of

80° F. nearly all hatch the sixth or seventh day after they are laid. Cool weather may retard hatching for a considerable time.

THE LARVÆ.

Newly hatched larvæ are somewhat more active than later, and owing to their extremely small size readily enter boxes or containers holding tobacco. When exposed to light, the larvæ disappear within the food substance or under cover as quickly as possible. They are able to crawl for short distances and often migrate from infested to uninfested material. This habit sometimes accounts for the quick appearance of injury in freshly made cigars. Partly grown larvæ shaken from leaf tobacco have been found on cigar makers' tables. These larvæ easily enter the open ends of the cigars, and in a very short time their work may be noticed in the bundle or box of finished cigars. Several cigars in a box or package may be injured by a single larva. Preference is shown for the thinner or chaffy leaves of cured tobacco, and for certain types of high grade that are mild and sweet flavored. (See fig. 3.) Strong, heavy types of leaf tobacco ordinarily are not injured to such an extent as are the milder or thinner types, unless stored for a long time. Leaf tobacco which is fire cured or smoke cured, such as that grown in the dark-tobacco sections of Virginia and in the "black patch" of Kentucky and Tennessee, seldom is badly injured. This is due in part, perhaps, to the flavor or quality given the leaf by the smoke, as well as to the natural qualities of tobacco of this type. The smoke seems to act for a time as a repellent, since the same type of leaf, flue cured, is attacked readily, although not to so great an extent as lighter bodied types. These types, as well as all others, however, are more likely to be injured after the leaf has become aged. The changes brought about by long storage of any tobacco seem in some way to make it more acceptable as food for the larvæ.

Length of larva stage.—At ordinary room temperatures in summer the larva or feeding stage extends over a period of from 30 to 70 days, depending mainly on the temperature and on the character, abundance, and condition of the food. In cold weather the larvæ become dormant and may remain in this condition for some time. It is mainly in this stage, in cool climates, that the insect passes the winter. When the larvæ have finished feeding and are incased within the pupal cells they are able, either as larvæ or as pupæ, to stand a considerable degree of cold. Larvæ within the cells are also more able to resist treatment with fumigants. Activity in the larva stage ceases at temperatures ranging from 60° to 67° F. The most favorable conditions for rapid develop-

ment of larvæ are a suitable food substance in a compact or concentrated form, high and uniform temperature, high humidity, and protection from strong light and from rapid evaporation.

The pupal cells.—After the larvæ have become fully grown and ready to transform to the pupa stage they construct cells or cocoons, usually within the food substance. In leaf tobacco these cells usually are found along the midrib or in folds of the leaf. In boxes of cigars some of the cells may be found between the cigars and the sides of the box, but the greater number are found within the cigar. In leaf tobacco the cells frequently are incomplete, the larvæ using folds of the leaf for part of the cells. Within dense substances the surrounding material forms the necessary protection, the walls of the cell being fragile and thinly lined. The cells are more or less egg-shaped and about one-fifth of an inch long. Often they are without definite shape.

The prepupa stage.—Before transformation to pupæ there is ordinarily a period of from 4 to 12 days during which the larvæ within the cells undergo structural changes, but if exposed to low temperatures they may remain in the cells for a considerable time before these changes take place. Before changing to pupæ the larvæ lie in a curved position within their cells, and their movements cause the cells to become considerably larger than the larvæ. Their bodies then contract and become more deeply wrinkled.

THE PUPÆ.

The pupa stage of the tobacco beetle at room temperatures during the warmer months of the year lasts from 5 to 10 days. The average of 38 records obtained at Tampa, Fla., during July, 1913, was found to be 7.8 days.

THE ADULTS.

When the change to the beetle or adult stage has taken place the beetles remain inactive in the cells for from 3 to 7 days. After emerging they remain at rest for a day or more, their color gradually deepening to reddish brown. At first the beetles are comparatively soft, and they do not attain their final degree of hardness until they are ready to move away from the pupal cell. They crawl or fly about actively and are capable of flying for a considerable distance. They avoid intense light and move about most actively in subdued light or in darkness. When in the dark they are attracted toward subdued daylight or to artificial light. In tobacco warehouses they may often be found in large numbers at the windows in late afternoon, the flight toward the windows being heaviest at sunset. Dur-

ing the day the beetles will be found most numerous in secluded places, such as crevices in the walls or in the leaf tobacco. They have a habit of feigning death when disturbed. The adults generally begin to mate the second or third day after becoming fully mature. In tobacco warehouses the beetles seldom are found active at temperatures below 65° F. Activity increases as the temperature becomes higher, but ceases between 117° and 120° F.

Length of the adult stage.—In warm rooms, or in summer, the beetles die much sooner than when emergence occurs during cooler weather. Although they may gnaw through tobacco or other food substances to escape from the locality where transformation took place, little evidence of feeding has been observed. Adults have been found to lay eggs and live the normal length of time whether food was present or not. Under usual conditions they live from three to six weeks.

Oviposition.—Egg laying usually begins in from two to six days after emergence. In warm places where tobacco is not subjected to temperatures much below 70° F., eggs may be found at any time. In the Middle and Northern States, where tobacco is kept in unheated buildings and the temperature is about the same as out of doors, the eggs are laid only during the warmer months of the year. In experiments at Richmond, Va., the last eggs were obtained from beetles kept in an unheated building on October 28, 1914, and the first eggs were obtained the following spring on May 2. There seems to be a rather common belief that the eggs are laid on the leaf of tobacco in the fields or during the process of curing, and that these eggs do not develop until the tobacco is handled or made up into cigars or other products. This is not the case, as the eggs at ordinary temperatures hatch a few days after they are laid, and the beetle does not infest tobacco until after it is cured. The eggs adhere very lightly to leaf tobacco and are dislodged easily by handling. The beetles deposit their eggs in crevices or folds of the leaf, or in secluded places away from the light, and where the closely packed food substance protects the eggs from evaporation. The egg-laying period normally lasts from 2 to 17 days, and the number laid by each female is approximately 25 to 30.

SUMMARY OF LIFE HISTORY.

The insect lives in its food substance during all stages of its existence. In tobacco or other food substance kept constantly warm breeding is continuous, and there may be as many as five or six generations a year. Under usual conditions in tobacco warehouses in the latitude

of Virginia and Tennessee there are three or four generations a year. The time required to complete the life cycle of the insect depends mainly upon temperature and may be as short as 45 days, normally varying in summer from 45 to 70 days. Eggs are laid in the food substance. They hatch in from 6 to 10 days. The larva period is from 30 to 50 days and the pupa period from 6 to 10 days. Under usual conditions adults live from three to six weeks. In temperate climates the insect passes the winter mainly in the larva stage. It thrives best where the temperature and humidity are high and in tobacco or other food substances protected from rapid evaporation.

SEASONAL ABUNDANCE AND NUMBER OF GENERATIONS.

In food substances kept constantly warm all stages of the beetle may be found at any time, and the great variation in the time required for development gives constant overlapping of generations. Under usual conditions in tobacco warehouses and in unheated buildings there are, however, well-marked periods when the adults are most abundant. In the latitude of Virginia and Tennessee there seems to be a period of greater abundance of the adults coinciding with the first warm weather in June, and again in August and early September. At Clarksville, Tenn., starting with the egg stage, in early May, three or, under some conditions, four generations are possible. At Richmond, Va., three generations may occur under warehouse conditions before the appearance of cold weather, the adults appearing in May, July, and October, and from the adults emerging earliest in the spring there may possibly be a fourth generation reaching the adult stage before winter.

NATURAL CHECKS.

Several natural agencies serve to check the increase and spread of the tobacco beetle, among which are low temperature, the drying out of food, the molding of food, parasitic and predatory insects, mites, jointed spiders, and false scorpions.

CLIMATIC CONTROL.

In the temperate zone a comparatively small proportion of the insects survive the winter when exposed to even moderate cold, long continued, or to sudden abnormal changes in temperature. Severe freezing at temperatures lower than 10 degrees above zero (Fahrenheit), even for a short time, exterminates them completely. Evidences of the effect of freezing on the tobacco beetle have been ob-

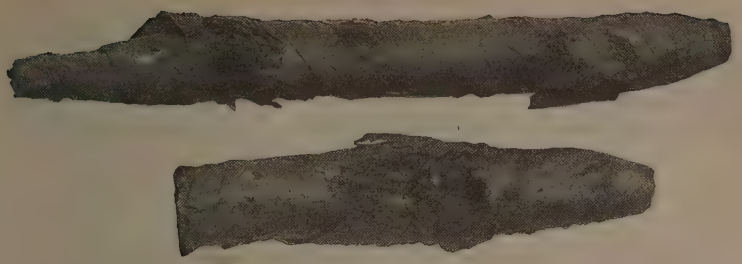

FIG. 5.—Cigars showing work of a solpugid, or jointed spider. The holes were torn by the solpugid in order to reach larvæ and pupæ of the tobacco beetle within the cigars.

served on many occasions, and it is not uncommon to find leaf tobacco or other food substances, which have been exposed to low temperatures, completely free from all live stages of the tobacco beetle, although its condition shows that there had been a heavy infestation previously.

DRYING OUT AND MOLDING OF FOOD SUBSTANCES.

The multiplication of the beetles is checked severely when the food substance is exposed to excessive evaporation, and when it becomes moldy, as it does frequently, more or less complete extermination of the beetles results. It is often owing to this fact that infestation from damaged or worthless products which have become moldy does not extend to uninfested products near by.

PARASITIC AND PREDACIOUS ENEMIES OF THE TOBACCO BEETLE.

INSECTS.

Among enemies that prey upon the tobacco beetle the most important, so far as known, is a reddish-brown beetle [1] about one-fourth of an inch in length. Both the adult and its larva, a pink worm slightly larger than the adult, feed ravenously on different stages of the tobacco beetle.

Several species of four-winged, wasplike parasites [2] of the tobacco beetle are found in infested warehouses and manufactured tobacco. Some of these are extremely abundant and doubtless are important factors in natural control.

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[1] *Thaneroclerus girodi* Chevrolat; order Coleoptera, family Cleridae.
[2] *Aplestomorpha pratti* Crawford, *A. vandinei* Tucker, and other species.

OTHER ENEMIES.

A small mite[1] feeds on the eggs of the tobacco beetle, and at Key West, Fla., a large jointed spider[2] (see fig. 5) and a much smaller scorpion-like spider[3] were found to feed on the larvæ. The jointed spiders frequently tear large holes in cigars in search of their prey.

REPRESSION.

PREVENTIVE MEASURES.

In cigar stores and small establishments it is not difficult to eradicate the tobacco beetle. Infested stock may be treated and the building thoroughly cleaned. The humidors or storage closets should be perfectly tight, and infested stock should be destroyed or treated as soon as signs of infestation are noticed.

In large factories and tobacco warehouses, however, complete eradication in many instances is extremely difficult, or perhaps impossible. The factories in some cases are old wooden buildings, roughly built and containing innumerable cracks and crevices in which tobacco dust and refuse have accumulated, offering ideal hiding and breeding places for the beetles. Even in modern factories of brick or concrete construction it is difficult to eradicate the insect completely after it has once become established, but it is much easier, of course, to keep such buildings clean and free from accumulations of refuse material in which the beetles may breed. The measures to be employed in eradication work or in sterilizing buildings will depend upon local conditions.

For destroying the different stages of the beetle in crevices of floors or walls, live steam applied through a nozzle from movable pipes or hose, hot water, gasoline, carbon disulphid, or dilute ammonia may be used. Suction cleaners also may be used to advantage for such work. (See fig. 6.) In cigar factories the stock of leaf tobacco should be kept in a tight or screened room, as far as possible from the rooms in which the cigars are made or handled. Trays of unsorted cigars should be covered or kept overnight in a screened compartment, as eggs deposited on the cigars at this time, even from a single beetle, may be the cause of heavy losses afterwards.

SOURCES OF INFESTATION IN FACTORIES.

In cigar and tobacco factories the greater number of beetles are brought in with the leaf tobacco. Beetles also breed from infested stock and from accumulations of refuse material. Factories in some

[1] *Cheyletus* sp.; class Arachnida, order Acarina.
[2] Class Arachnida, order Solpugida.
[3] Class Arachnida, order Pseudoscorpiones.

instances are in close proximity to tobacco warehouses where beetles are present in large numbers. A comparatively small number of beetles in rooms in which cigars are made, or in rooms where the cigars or other classes of manufactured tobacco are packed, is sufficient to infest the stock seriously by depositing eggs in it. The protection of the finished product before it is packed is generally of more importance than the condition of the raw material, as with most classes of manufactured tobacco the process of manufacture frees it from different stages of the beetle present in the raw material.

COLD STORAGE.

The modern cold-storage plants now found in most cities furnish a convenient, inexpensive, and effective means of sterilizing infested tobacco. The method has been used to a considerable extent, but the temperatures more commonly used have the effect of suspending insect activity instead of causing death. Cold storage at temperatures between 32° and 65° F. prevents further damage as long as the material is held in storage. The different stages of the beetle are not killed, however, and activity is resumed when the tobacco is removed from storage. When lower temperatures are available a more satisfactory and effective method is to subject the tobacco for a week or more to the lowest temperature that can be obtained. A long series of experiments with infested tobacco in cold storage at low temperatures has shown this method to be thoroughly effective.

The cold-storage room should be as dry as possible, and the cigars or manufactured tobacco should be removed from storage when the air outside is dry, to prevent sweating. Some system of dry cold storage

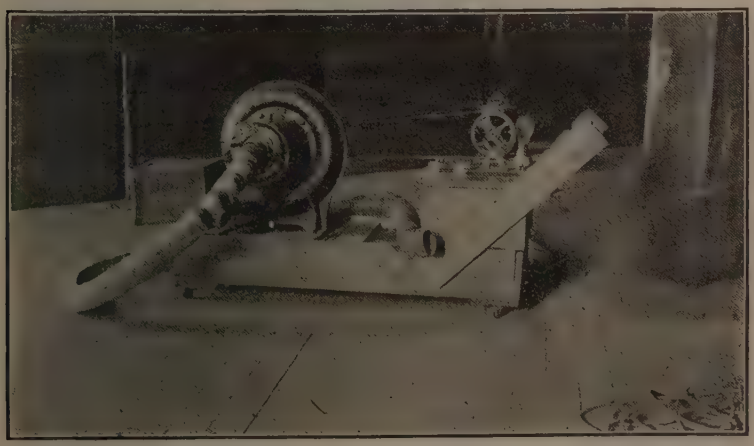

FIG. 6.—Suction fan used for collecting adults of the tobacco beetle in a tobacco warehouse.

or air-tight receptacles for holding the cigars or tobacco is desirable, although not absolutely necessary if care is taken to remove the material when the air is dry. If the material is removed from storage when the air is damp, the condensation of moisture may make the tobacco or cigars more liable to mold, or may cause discoloring, staining, or warping of the boxes or containers.

A large number of cigars placed in cold storage by a manufacturer were kept under observation by the writer. The cigars were not put in containers, the boxes being merely piled on the floor of the cold-storage room. The boxes were removed when the air outside was dry and put under presses in a dry room for a time to prevent warping of the covers of the boxes. The treatment proved thoroughly effective in killing all stages of the beetles. The manufacturer reported that no injury to the cigars as a result of the treatment was apparent. Different lots were kept at a temperature of about 12° F. for from one to four weeks.

Although there are certain objections to the cold-storage method of control, such as loosening of the wrappers of fine cigars by sudden changes in temperature, danger of sweating when removed from cold storage, injury to quality from too rapid aging, etc., it has certain advantages and in some cases may be found more desirable than other methods of treatment. When precautions are taken to prevent sweating, it is evident that the exposure of manufactured or leaf tobacco to cold in a cold-storage room is not more apt to cause injury than the exposure of the same material to low temperatures during winter.

FREEZING DURING WINTER.

In localities where severe freezing occurs the doors and windows of warehouses or other buildings where tobacco is stored may be thrown open at favorable times during the winter and the tobacco subjected to freezing temperatures. This control measure has been employed by tobacco men in different sections of the country, and excellent results have been reported, the degree of success in exterminating the beetles or checking their increase depending upon the temperatures obtained. Experiments made with infested manufactured tobacco have shown that it may be sterilized easily by this means.

The modern practice of storing certain classes of leaf tobacco in hogsheads in sheds, giving practically out-of-door conditions and variations of temperature, furnishes an effective means, in cool climates, of reducing injury to leaf tobacco which may be stored in this manner.

ALTERNATIONS OF HEAT AND COLD.

Experiments made with infested tobacco indicate that the effectiveness of cold in killing different stages of the beetle can be increased by alternations of heat and cold. Sudden and extreme changes in temperature seem more destructive to the beetles than longer exposures to moderate cold. This method is applicable also to cold-storage treatment of infested tobacco.

EFFECT OF HEAT ON DIFFERENT STAGES OF THE TOBACCO BEETLE.

It has been found that adults of the tobacco beetle become inactive after a few minutes' exposure to heat above 117° F., but recover unless, for a considerable length of time, the temperature is kept higher than 120°. An exposure of one hour at temperatures between 140° and 150° proved effective in killing all stages of the beetle. The time required for treatment depends upon the quantity and character of the material. A temperature of from 125° to 140° F., continued for a few hours, or of 150° for a short time, has been found effective under ordinary conditions.

EFFECT OF HEAT DURING THE PROCESS OF MANUFACTURE.

Tests made in tobacco factories have shown that the temperatures reached during certain processes of manufacture are sufficiently high to sterilize the tobacco quickly and effectively as it passes through the driers.[1] Reinfestation of the finished product depends on the methods of packing, handling, and storing.

THE USE OF STEAM IN STERILIZING TOBACCO.

While steam furnishes, under some circumstances, an effective and convenient means of sterilizing empty storage rooms or warehouses, numerous difficulties prevent its use in sterilizing infested tobacco. If leaf tobacco is exposed to steam at high temperatures for any length of time it becomes more brittle, the texture of the leaf and the aroma are changed as the natural oils are drawn out, and the color becomes darker. Notwithstanding the general prejudice against steaming, however, there seems to be considerable evidence that mild steaming may be employed to advantage in treating certain classes of cigar tobacco, and the process is said to have been used to a considerable extent. A convenient method of steaming cigar tobacco in revolving drums, with the steam under pressure of about four atmospheres, is said to have been used successfully in the Philippines.[2] In

[1] Several tests showed that a temperature of about 180° F. was reached.
[2] The Philippine Journal of Science, v. 8, no. 1, 1913.

the application of steam the principal requisite is to see that the tobacco does not become too wet. The temperature should not be too high or the steaming be long continued.

TRAPPING.

In rooms where cigars or manufactured tobaccos are packed a very few beetles are capable of doing a great deal of damage by depositing eggs on the finished product. In many cases the process of manufacture has sterilized the tobacco thoroughly, and precautions to keep the beetles away during the time it is handled and packed will prevent damage to the product later. The windows of packing rooms should be examined daily and the adults destroyed by brushing them onto sticky fly paper, or by other means. The adults are readily attracted to hands of leaf tobacco suspended in the rooms and may be collected in this way. The leaf tobacco used for this purpose should be heated or fumigated once each week in order to destroy the eggs before they have time to hatch. The adults are attracted toward the light, and an effective means of trapping consists of inclosing electric lights in sticky fly paper. (See fig. 7.) Sheets of fly paper spread on the window sills also were found to destroy many beetles. The adults fly more readily to blue or violet light than to red or orange. Color screens, however, cut down the intensity of a light. Ordinary electric-light bulbs of clear glass, of the improved and nitrogen-filled types, which transmit light rich in rays of short wave lengths, are well adapted for use as sources of light in connection with trapping.

FIG. 7.—Arrangement for using sticky fly paper to collect adults of the tobacco beetle in tobacco warehouses.

FUMIGATION.

Fumigation has been in general use for many years as a method

of destroying certain classes of insects and is a standard weapon against insects infesting mills and warehouses. It may be used to advantage in controlling the tobacco beetle, although this pest has been found to be considerably more resistant to fumigants than most insects. The insulation afforded by the pupal cells and by compressed tobacco seems to protect the larvæ or pupæ within from the action of the fumigant. A few insects protected in this manner are likely to survive, although all stages not specially protected are killed. In most cases, however, only a small percentage of the insects survive, and these, if an additional treatment is thought advisable, may be destroyed by a second fumigation given about two or three weeks later. Adults and eggs are the only stages likely to be present at this time, and these unprotected stages are easily destroyed by the fumigant. In the treatment of infested tobacco it has been determined by many experiments that stronger dosages of fumigants must be used than are employed ordinarily against other insects.

Expert tobacco men have examined and kept under observation tobacco and cigars fumigated with carbon disulphid and hydrocyanic-acid gas, and all were of the opinion that these fumigants had no noticeable effect upon the tobacco. In order that it might be determined whether or not any deposition of cyanogen in cigars occurs as a result of the hydrocyanic-acid gas treatment, different lots of freshly made cigars were fumigated with heavy dosages and sent to the Bureau of Chemistry, United States Department of Agriculture, for examination. No trace of hydrocyanic-acid was found in any of the samples. Duplicates from each lot were also submitted to expert cigar men, and all reported no apparent difference between the fumigated and unfumigated cigars.

The properties and characteristics of the various chemicals used in fumigation should be understood thoroughly in every particular by the operator in order that necessary precautions may be taken and the work done properly. The process of fumigation, however, is simple and easily applied.

HYDROCYANIC-ACID GAS.

For the generation of hydrocyanic-acid gas in fumigation, sodium cyanid (NaCN) or potassium cyanid (KCN), sulphuric acid (H_2SO_4), and water are necessary. The hydrocyanic-acid gas,[1] which is the killing agent, is produced by the action of the sulphuric acid (diluted with water) on the sodium or potassium cyanid. A high grade of the cyanid should be used, as the presence of adulterants reduces greatly the amount of hydrocyanic-acid gas given

[1] Hydrocyanic-acid gas is colorless and one of the most deadly poisonous gases known.

off. Sodium cyanid at present is used for fumigation more generally than is potassium cyanid and is more readily obtained.

Dosages to use.—Sodium cyanid should be combined with acid and water to generate the hydrocyanic-acid gas, according to the following formula:

Sodium cyanid (grade guaranteed to contain not less than 51 per cent of cyanogen and practically free from chlorin)	avoirdupois ounce	1
Sulphuric acid (commercial[1])	fluid ounces	1½
Water	do	3

Should potassium cyanid be used in place of sodium cyanid,[2] the cyanid should be combined with sulphuric acid and water according to the following formula:

Potassium cyanid (98 to 99 per cent grade and guaranteed to contain not less than 38.4 per cent cyanogen)	avoirdupois ounce	.1
Sulphuric acid (commercial[1])	fluid ounce	1
Water	fluid ounces	3

The amount of chemicals given in either of these formulas is sufficient for the fumigation of 100 cubic feet of space in the fumigation closet or room. The exposure to fumigation should last at least 24 hours. Best results are obtained by fumigating at temperatures above 70° F. For general use 4 ounces of cyanid, either of sodium or potassium, to 100 cubic feet will be found fairly satisfactory. This dosage when sodium cyanid[3] is used requires 4 ounces of cyanid, 6 fluid ounces of sulphuric acid, and 12 fluid ounces of water. The cyanid is weighed, and the liquids, sulphuric acid, and water are measured.

For generators use earthenware jars, and these should be deep enough to prevent the liquid from boiling over. Since the gas generated is lighter than air, *place the generator underneath the material to be fumigated or on the floor of the room.* Place the chemicals for fumigating in the generating jar in the following order: *First, water; then sulphuric acid; last, just before closing the fumigating closet or room, the cyanid. Do not pour water on to the acid. Avoid breathing the gas, as it is deadly poisonous. The reaction of the chemicals*

[1] Commercial sulphuric acid (about 1.84 sp. gr. or 66° Baumé) which is approximately 93 per cent pure is commonly used for fumigation.

[2] The yield of hydrocyanic-acid gas from 1 ounce of high-grade sodium cyanid is equivalent to the yield from approximately 1½ ounces of high-grade potassium cyanid.

[3] Sodium cyanid is now on the market in molds or "eggs" weighing 1 ounce each. It is advisable to use this form, since it is easily handled and the necessity for weighing is obviated. *The poison should be kept in tight cans, properly labeled, and extreme care should be taken in handling it. Sodium cyanid and potassium cyanid are among the most poisonous substances known.*

when mixed is extremely rapid, and the generation of the deadly gas begins at once.[1]

The fumigation closet should be perfectly tight to prevent escape of gas. In fumigating storage rooms or buildings, arrange so that the windows or doors can be opened from the outside. *Do not enter the room until it is thoroughly aired.* When the chemicals are handled with care and all details of the method understood, there is no special danger to the operator, and the method has been used in insect control for many years with few records of serious accidents. It should be stated, however, that hydrocyanic-acid gas is fatal to human beings if breathed in any quantity.[2]

CARBON DISULPHID.

While carbon disulphid is not as effective as hydrocyanic-acid gas, the ease with which it may be used makes it for some purposes the more desirable fumigant, particularly when the space to be fumigated is small or when only a small quantity of material is to be treated. The liquid carbon disulphid (CS_2) merely has to be poured into a shallow dish placed *at the top* of the compartment to be fumigated and allowed to evaporate. The gas is heavier than air and settles downward. This methods of treatment is a favorite one with many cigar dealers, the main objection being the danger of fire.[3] Carbon disulphid should be used at a rate of not less than 4 pounds of the liquid to 1,000 cubic feet of space. When only a small space is to be fumigated and the cost of the treatment is consequently slight, the exact amount of the carbon disulphid is of no particular importance, providing the amount is in excess of the dosage recommended. Best results are secured at temperatures above 70° F. The time of exposure should be from 24 to 48 hours. All odor of the fumigant disappears quickly when the substance treated is exposed to the air. Tobacco or cigars, when properly aired, do not retain even the slightest trace of the gas, and quality and flavor are not changed perceptibly.

DESTRUCTION OF TOBACCO BEETLE BY MEANS OF ROENTGEN RAYS.

A process of destroying the tobacco beetle in cigars at the factories by the use of Roentgen rays has been exploited commercially and the method of treatment and apparatus used for the purpose at the pres-

[1] Care must be taken in fumigating buildings in close proximity to dwellings, as the liberation of a large volume of hydrocyanic-acid gas may endanger the persons within the dwellings.

[2] In case of accidental inhalation of the gas, the person affected should be kept in the open air and be required to walk to increase respiration.

[3] Carbon disulphid vapor is highly inflammable and explosive when mixed with air in certain proportions, but it is not more dangerous to handle than gasoline. The fumes should not be breathed, as the gas is poisonous.

ent time give apparently satisfactory results. By this method the cigars in sealed boxes, ready for shipment, are subjected to Roentgen-ray radiation of great power and intensity. Recent improvements in apparatus have made possible exposures which could not be obtained readily or were not practicable in commercial work with earlier forms of apparatus.[1]

[1] A detailed report of experiments made by the writer with X rays has been published in the Journal of Agricultural Research, Vol. VI, No. 11. "Effect of Roentgen rays on the tobacco or cigarette beetle and the results of experiments with a new form of Roentgen tube." Washington, Government Printing Office, 1916.

PUBLICATIONS OF THE UNITED STATES DEPARTMENT OF AGRICULTURE RELATING TO INSECTS INJURIOUS TO TOBACCO.

AVAILABLE FOR FREE DISTRIBUTION BY THE DEPARTMENT.

Tobacco Budworm and its Control. (Farmers' Bulletin 819.)

Tobacco Hornworm Insecticide: Recommendations for Use of Powdered Arsenate of Lead in Dark-tobacco District. (Farmers' Bulletin 867.)

Tobacco Splitworm. (Department Bulletin 59.)

Methods of Controlling Tobacco Insects. (Entomology Circular 123.)

FOR SALE BY THE SUPERINTENDENT OF DOCUMENTS, GOVERNMENT PRINTING OFFICE, WASHINGTON, D. C.

So-called Tobacco Wireworm in Virginia. (Department Bulletin 78.) 1914. Price, 5 cents.

Tobacco Thrips and Remedies to Prevent "White Veins" in Wrapper Tobacco. (Entomology Circular 68.) 1906. Price, 5 cents.

Tobacco Thrips, a New and Destructive Enemy of Shade-grown Tobacco. (Entomology Bulletin 65.) 1907. Price, 5 cents.

Principal Insects Affecting Tobacco Plant. (Farmers' Bulletin 120.) 1900. Price, 5 cents.

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